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FLEXIBILITY FOR VOCATIONAL EDUCATION THROUGH COMPUTER SCHEDULING.

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DESCRIPTORS- *VOCATIONAL EDUCATION, *VOCATIONAL SCHOOLS, *SCHEDULING, SIMULATION, *COMPUTERS, STANFORD, CALIFORNIA, STANFORD SCHOOL SCHEDULING SYSTEM

A DEMONSTRATION PROJECT WAS INITIATED TO SHOW THE FEASIBILITY OF INTRODUCING GREATER FLEXIBILITY INTO VOCATIONAL CURRICULUMS AND INTO THE PREVOCATIONAL DIMENSIONS OF NONVOCATIONAL CURRICULUMS THROUGH THE USE OF A COMPUTER-BASED SCHEDULING TECHNOLOGY. RESEARCH WAS PLANNED TO COVER A 3-YEAR PERIOD. THE 1ST YEAR'S RESEARCH WAS COMPLETED MAY 1, 1966, AND WAS THE TOPIC OF THIS REPORT. THE TWO TYPES OF SCHOOL INVOLVED WERE VOCATIONAL-TECHNICAL AND COMPREHENSIVE. THE CRITERIA USED IN THE SELECTION OF SCHOOLS INVOLVED A BALANCE AMONG RURAL, SUBURBAN, AND URBAN LOCATIONS AND A VARIETY OF TYPES IN GRADE ORGANIZATION, ENROLLMENT, AND POPULATION SERVED. RESULTS OF THE 1ST-YEAR EFFORTS INCLUDED (1) IDENTIFICATION OF RELEVANT AREAS TO BE INVESTIGATED DURING THE FINAL 2 YEARS, (2) COLLECTION OF BASELINE DATA TO BE USED IN A BEFORE-AFTER DATA COMPARISON, (3) EMPLOYMENT OF A COMPUTERIZED TECHNIQUE FOR CURRICULUM SIMULATION, AND (4) DEVELOPMENT OF A MULTIPLE REGRESSION TECHNIQUE FOR THE ANALYSIS OF CURRICULUM SCHEDULING. IT WAS CONCLUDED THAT THE PRINCIPAL PROJECT OBJECTIVE WOULD REMAIN UNCHANGED DURING THE FINAL 2 YEARS OF THE RESEARCH. (LP)

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FINAL REPORT
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# FLEXIBILITY FOR VOCATIONAL EDUCATION THROUGH COMPUTER SCHEDULING

July 1966

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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# FLEXIBILITY FOR VOCATIONAL EDUCATION

# THROUGH COMPUTER SCHEDULING

ERD-188

CONTRACT NO. OE-5-85-071

DWIGHT W. ALLEN

JULY, 1966

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

LELAND STANFORD JUNIOR UNIVERSITY

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ACKNOWLEDGEMENTS

The list of people who have contributed to the success of this first year of our research is extensive indeed. We extend our appreciation to our Vocational Education Advisory Committee, to our own staff, and to the teachers and administrators of participating schools. We are particularly indebted to Dr. Franklin Keller who served as a Research Associate and who ably assisted us as we attempted to delineate the areas we would investigate intensively during the remaining two years of our endeavors.

# I. INTRODUCTION

## The Problem

Recent legislation for the support of vocational education offers schools opportunities to redesign their programs of vocational and pre-vocational training. In the past, tradition and available scheduling techniques have contributed to a typically uniform pattern of grouping students. Relaxing traditional uniformity should encourage schools to improve their programs of vocational educational on three fronts.

First, schools will be able to provide better balance in the total program for vocational students in comprehensive or in specialized vocational schools. Second, they will be able to provide more pre-vocational and vocationally-oriented experiences for pupils enrolled in non-vocational curriculums. Third, they will be able to introduce flexibility in course design which takes into account unique student abilities and interests, teacher talent, and course content through variation in class size, duration of class meetings, number of class meetings per week, and teacher assignment.

The restriction on opportunities for vocational pupils to pursue a balanced program showed itself in a recent analysis of thirteen curriculums offered in the public secondary schools of Philadelphia(1). The design of the several curriculums revealed that pupils enrolled in the vocationally oriented curriculums in the comprehensive high schools (e.g., commercial, clerical, homemaking, trade preparatory) enjoyed the least opportunity to elect courses which could contribute to a broad, comprehensive educational experience. The courses required by their vocational choice and by a uniform but limited general education requirement virtually exhausted all of the pupil time available. The three basic curriculums in the vocational schools (technical, vocational, and trade) were almost completely prescribed. In general, pupils in the vocational curriculums -- whether lodged in comprehensive high schools or in specialized vocational schools -- were permitted only one choice of a two-period per week minor elective in each of the six semesters of the three senior high schools years. In several of the vocational curriculums, the choice of an elective minor was reduced to only one period per week in each of two of the six semesters.



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Analysis of programs actually completed by a sample of Philadelphia secondary school graduates and the relationship of these programs to post high school careers also revealed that a significant proportion of those who had enrolled in college preparatory curriculums entered the world of work immediately after graduation. Most of them, and also the pupils enrolled in so-called "general" courses, entered the job market with little understanding of the territory and without marketable skills, Our concern for vocational education, then, transcended the limits of vocational schools and vocational curriculums in comprehensive high schools. It reached into the opportunities for vocational experiences of pupils in non-vocational curriculums.

In general, vocational curriculums typically have consisted of two basic elements: first, shop work and related "theory" courses; second, general education requirements. Often a third element, work experience, was included. Prior to the Vocational Education Act of 1963, government regulations required the scheduling of shop work and related courses for a one-half day block in programs which qualified for state and federal assistance. General education requirements varied according to state and local regulations; but an illustrative pattern for grades 9 - 12 would consist of three or four years of English, two or three years of social studies, one year of mathematics, one or two years of science, and four years of physical education. The related "theory" courses typically included some work in mathematics and science specifically relevant to the vocational field for which the pupil was receiving his preparation.

Instructors attempted to differentiate within vocational courses according to the ability and performance of individual students. Indeed, the performance charts of progress which many vocational shop teachers used as standard practice represented significant strides in individualizing instruction. Yet, the very block-of-time base of their courses tended to encourage them to set tasks in a pattern and sequence which permitted the average student to start and to finish a given activity only in the time specifically scheduled for doing so. What the average student could do in this period of time, the more able could do in less time and the less able could not match.



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A brief example of how a school could substitute a "performance" criterion for a "time" criterion will illustrate the way in which flexibility in course design can accomodate variations in student ability and interest. At the beginning of the year, the instructor and each pupil determine the projects which they agree the pupil should undertake. The appropriateness of the project is specifically related to the aim of the course. The instructor and the pupil together establish the worth of each project in terms of school units. The pupil earns these units when he and the instructor agree that he has completed the project satisfactorily -- whether the pupil does the job in one day, one month, one semester, or one year.

Variation in length of time to complete the project is related, of course, to pupil ability and interest. Variation is also related to accessibility of shops and laboratories. The school would designate each of its shops and laboratories as "closed" for certain periods of the day -- usually a minimal amount of time -- and "open" for other periods of the day. The schedule is posted for pupil reference. He can then go to an "open" shop during time which is provided him for independent or individual study.

The connection between open shops or laboratories and time provided to pupils for independent or individual study is clear. Unless pupils do have some time in their schedules reserved for independent or individual study, there will be no one available to use shops or laboratories on an open basis.

The notion of course design based on performance does not depend solely on the availability of open shops or laboratories. Teachers and pupils can "contract" for completion of tasks or projects within periods of conventional length in closed shops or laboratories. It is clear, however, from observation that the open shop or laboratory has materially advanced accomodation of variation in student ability and interest. Also, teachers who previously met conventionally scheduled classes (set number of pupils at set times for periods of set length) report not only marked satisfaction with combinations of closed and open shops and laboratories but also marked improvement in their ability to help larger number of pupils to perform at a high level.



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The foregoing analysis raised three strategic questions about the improvement of vocational education. First, "Can vocational schools and comprehensive secondary schools which offer vocational curriculums provide richer and more balanced general education programs for vocational pupils?" Second, "Can comprehensive secondary schools provide more opportunities for pupils enrolled in non-vocational curriculums to participate in desirable pre-vocational or vocationally-oriented experiences?" Third, "Can vocational educators and their colleagues conceptualize and implement alternative ways for the more profitable and productive use of time, student abilities and interests, teacher talent, and school facilities?"

## Objectives

The objectives of the proposed demonstration fell into categories: general and specific. The objectives were conceived for a three-year project, only one year of which is covered by this report.

General Objectives. The general objective was to demonstrate that it is feasible to introduce greater flexibility into vocational curriculums and into the pre-vocational dimensions of non-vocational curriculums. It was believed that the availability and use of SSSS would encourage and permit educators to design vocational courses which use staff, time, facilities, and grouping of students in new and different ways.

A secondary objective was to demonstrate that SSSS can be used appropriately and economically by large numbers of secondary schools. One of our goals was to place SSSS in the public domain as soon as possible, so that it would be generally available to schools throughout the nation. Initial steps have been taken to achieve this goal along two fronts -- first, continuous refinement and improvement in the system to convert it to a production model free from dependence on a small group of inventor-developers and technologists based at Stanford and second, establishment of liaison and working relationships with strategically located computer and data processing centers such as the University of Iowa and Michigan State University. Such centers will serve schools in their own geographic area. Use of SSSS does not require a school or school system to rent or purchase its own computer and associated data processing equipment.

The actual costs of generating schedules for twenty-six schools indicate the ultimate economic feasibility of widespread adoption of the basic technology. However, experimental scheduling and associated developmental activities, which have characterized operations to date, are substantially more expensive to undertake than scheduling on a production basis. More representative cost data will be collected, and SSSS will be converted to a production system during the period of demonstration. Both factors will work to the ultimate benefit of schools which intend or hope to use the system.

Central to the proposal for widespread use and dissemination of SSSS is the benefit to school administrators and other professional personnel in the form of relief from the tedium and restrictions of conventional schedule construction. This relief and freedom can prompt and help them to seek ways to use the enabling technology for improving the quality of education in their total programs.

Specific objectives. The following hypotheses encompassed the specific objectives of the proposed demonstration. Data were collected for testing each hypothesis in participating schools on a "before" basis. "After" data will be collected in the second phase of the project, a phase not covered by this report.

As a result of employing SSSS as an enabling technology:

1. There will be an increase in the number and variety of courses offered to pupils in both vocational and non-vocational curriculums. There will also be an increase in the number of students receiving pre-vocational educational experiences.

2. There will be changes in course design which reflect an increase of variability in instructional settings -- specifically in the increased use of large-group and small-group instruction, in the differentiated and varied use of shops and laboratories, and in opportunities for independent and individual study. These changes will take place even in schools which initially anticipate no departures from conventional course design.

3. There will be changes in course design which are specifically related to the uniqueness of the subjects involved. For example, the amount and spacing of large-group and

small-group instruction in shorthand and typing will vary from the amount and spacing of large-group and small-group instruction in mechanical drawing or metal shop.

4. The differentiation in the content of parallel courses within a subject field for students of different abilities and interests will be increased. For example, automobile shop pupils who have the ability and interest to do so will be able to study more and more difficult related mathematics and science than will automobile shop pupils who are less able in mathematics and more interested in practical application. Related course content may be used in one course to develop skills in general education. For example, a student may learn a shop procedure and then be asked, as a part of English competence, to write a description of that procedure for inclusion in a shop manual. His competence is tested when another student attempts to follow that procedure.

5. Students will be provided more opportunity and will assume more responsibility for their own learning and behavior. For example, each pupil's schedule will include time reserved for independent and individual study which he may undertake in the library, specific subject resource centers, "open" shops or laboratories, or in consultation with guidance counselors, teachers and peers. The idea of the "open" laboratory or shop is that the student can go to the laboratory or shop during his independent study time to work on either assigned or optional tasks. It is assumed that the laboratory or shop will be appropriately supervised when it is open. The advantage of the "open" laboratory is that the individual student will be able to spend the time there that is required for him to accomplish his task satisfactorily. Emphasis is placed on individual aptitudes, abilities, and responsibility in vocational education.

6. Students' programs will reflect increased recognition of variation in their abilities and interests. For example, within the total group of pupils who elect a given vocational curriculum (say the commercial), the



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amount of time pupils are assigned to specific elements (such as typing, shorthand, mathematics, Business English) will vary according to levels of performance and individual work patterns rather than be uniform for all.

7. Teachers' and pupils' schedules will provide increased opportunity for extended individual contact. The schedules for teachers and pupils will both contain substantially more open or unassigned time than conventional schedules currently provide. The additional unassigned time will encourage and permit more face-to-face contact by individual pupils with individual teachers.

8. Teacher assignments will reflect increased differentiation specifically related to professional preparation and special teaching competence. Instructors who are specialists in subphases of a subject field (such as ignition systems in automotive engineering) will be able to provide instruction for all pupils in a given vocational curriculum. Instructors who have a flair for large-group instruction will be able to concentrate their efforts in such a setting, while instructors who are especially competent in small-group or individual conference will be able to concentrate on these phases of the total program. It should not be assumed that small-group and individual instruction is necessarily easier than large-group instruction. Some teachers can perform more effectively in a large group setting while others are more effective in a different setting.

9. Teacher performance will reflect increased and extended staff cooperation. Cooperative professional planning of total curriculum patterns, of specific courses and their design, of division of labor according to teacher talent and interest, and of joint teaching of different groups of pupils will flow from and be required by employment of SSSS and the schedules it can generate.

10. Administrator participation in schedule construction will emphasize increased attention to professional decisions as contrasted with clerical and routine details. Freedom from the tedium of manual schedule generation will encourage and enable administrators to exercise conceptual leadership in planning total programs and in devising variable course designs.

## II. METHOD

### Description

It was proposed that the use of a computer-based scheduling technology would contribute to the improvement of vocational education by helping schools to introduce flexibility in course design. By flexibility in course design, we referred to planned variation in the assignments of teachers, the grouping of students, and the use of time and space. It was believed that introducing flexibility in course design could help vocational educators to provide more balance in the total program of vocational pupils and to provide more pre-vocational and vocationally-oriented experiences for pupils enrolled in non-vocational curriculums.

The demonstration was carried out through four sets of developmental pilot schools using the Stanford School Scheduling System (hereafter referred to as SSSS and described in detail on pages 10 - 13.

The first set of pilot studies was made in schools which had already demonstrated an interest in significant modification of course design and in which a majority of pupils do not continue their education beyond high school. Schools were selected from the group which have been associated with the Stanford Flexible Scheduling and Curriculum Study during the years of development and field test of SSSS. These schools - all comprehensive high schools were to serve as centers for demonstrating the feasibility of employing SSSS (1) to introduce changes in vocational courses, (2) to provide richer and broader general educational experiences for vocationally-oriented pupils and, (3) to provide more opportunities for non-vocationally oriented pupils to participate in appropriate and profitable pre-vocational or vocationally-oriented experiences.

The second set of pilot studies was made in schools - both specialized vocational and comprehensive - where the professional personnel had signified an intent to remain with conventional scheduling patterns but had indicated an interest in employing computer technology to generate their schedules. We justified the inclusion of this set of schools because of our prediction that the administrators in these schools would be more receptive to consideration of alternative course designs as they found

themselves relieved of the operational details of schedule construction. During the pilot study period, the personnel of these schools were systematically exposed to the capabilities and limitations of computer-based scheduling for realizing alternative curriculum decisions as well as to the economic feasibility of computer-based construction of both conventional and flexible schedules.

The third set of pilot studies was made in schools - both specialized vocational and comprehensive - in which the professional personnel were already interested in introducing changes aimed at improving the effectiveness of vocational education but which required the enabling technology of SSSS to implement the improvements.

The fourth set of pilot studies was made in schools selected for testing the applicability to vocational education of the full set of assumptions developed by Bush and Allen(2). A central premise of their proposal is that students with specialized interests, vocational or otherwise, will have the opportunity to develop genuine competence by pursuing their field in depth over a period of several years. They also recommended that:

1. All pupils should have continuous study in all years of secondary school in all basic subject matter fields, including the arts, languages (English and foreign), mathematics, natural sciences, physical education and health, social sciences, and guidance.

2. In each subject field, several groups of pupils whose abilities and interests are sufficiently distinct to require a discrete program of studies can be identified.

3. A subject, for its proper instruction, may require as many as four basic settings: independent and individual study, small-group instruction, laboratory instruction, and large-group instruction.

4. Adequate instruction in each subject matter field typically requires senior teachers who are both well trained in their fields and highly skilled in teaching and who are assisted by less highly trained members of the instructional staff.

5. Class size, length of class meeting, and the number and spacing of classes should vary according to the nature of the subject, the type of instruction, and the level of ability and interests of pupils.

Work experience, vocational training, and a broader general education can be provided in a program so conceived.

The propositions advanced by Bush and Allen encompass complex and intricate variables representing pupils, instructors, facilities, and course patterns. The structural variables are explicit. The variable of course content is implicit. The evidence from schools across the country which have attempted to incorporate several of these and similar innovative proposals into their total programs is that an enabling scheduling technology is needed to permit them to handle the variables involved in constructing their master schedules.

## The Stanford School Scheduling System

The Stanford School Scheduling System is an enabling technology. SSSS was invented and developed to permit schools to incorporate into their total programs as number of far reaching proposals for the redefinition and redeployment of time, talent, and technology. Five years ago, the application of computer technology to the actual generation of secondary school master schedules was only a hope and an idea. Today, that application is a matter of demonstrated record.

Early in the development of the proposals that are presented in A New Design for High School Education, it was correctly recognized by the authors that the anticipated variety and complexity in course patterns made manual scheduling impracticable. At this stage, the authors enlisted the services of Professor Robert V. Oakford of Stanford's Department of Industrial Engineering, a specialist in computer operations, in the invention and development of a computer-based technology for school scheduling.

The Fund for the Advancement of Education of the Ford Foundation made two grants, the first for a pilot analysis of feasibility and the second for development and field test of a computer system for scheduling. The grants terminated in August, 1963. By that time, SSSS had successfully generated both flexible and conventional schedules for four pilot schools.

Under the aegis of the Flexible Scheduling and Curriculum Study, Stanford has pioneered in computer based scheduling. Preliminary work in this area is reported in an Engineer's Thesis submitted to the Department of Industrial Engineering at Stanford University by Charles R. Pack in 1961(3). Oakford and his staff developed an experimental version of SSSS, which was field tested in the summer of 1963. The test involved construction of schedules for four schools which had indicated an interest in introducing variety of course design into their total programs. While not ideal, the schedules were usable.

Since the summer of 1963, development of the SSSS has continued. Part of the refinement and improvement is the result of knowledge gained during the 1963 first test. Part was made possible by the addition of disc storage to the IBM 7090-SUBALGOL system at Stanford. A second field test in the summer of 1964 involved the same schools that participated in 1963, together with many new ones that had requested assistance.

SSSS, as an enabling technology, does not require a school to adopt one particular pattern of curriculum design or content. SSSS is a general purpose system of computer programs, capable of generating schedules either when variability is introduced in course design or when course design is conventionally uniform. Of twenty-six school schedules generated in 1964-1965, twelve introduced appreciable variability in course design, ten were conventional, and four were a combination of both.

In keeping with its curriculum inspiration, however, SSSS not only permits but requires that a school specify in detail the total curriculum which the school wishes to offer. The alternatives which the system makes available to schools permit and encourage the professional personnel to make curriculum decisions which they believe are optimal for the courses they will teach. Time becomes a resource to use to achieve specific purposes rather than remaining a Procrustean restriction. Size of classes, length of class meeting, number of meetings per week, mode of instruction (individual study, small-group, large-group, laboratory), teacher assignment, pupil grouping -- all of these variables the professional personnel can consider as related in their judgement to the general and specific purposes they wish to achieve.

The input requirements of SSSS stipulate that curriculum decisions precede the preparation of input data. The preparation of input data itself is a clerical operation. The curriculum decisions which shape the input data constitute a high-level professional task. Freedom from the aribitrary limits which conventional schedule construction imposes on the specification of variability in course patterns dramatically enlarges the breadth and depth of curriculum decisions which the professional personnel can consider. The discipline introduced by dialogue with the computer at the same time forces sharp analysis of the connection between ends and means. In sum, SSSS does not usurp the professional curriculum decisions of a school faculty; indeed, its use fosters individuality in curriculum design.

The input stage of SSSS terminates with the preparation of curriculum data in a form compatible for translation into computer language. The curriculum data comes from each school to a computer center (in this instance, the Stanford Computation Center) on seven different decks of punch cards, prepared locally; that is, the cards are prepared by the school itself. The seven decks of cards include the following information: (1) school schedule boundary specifications, such as number of days in the schedule cycle, number of periods in a day, lunch periods, number of course requests permitted each pupil; (2) corrections, which specify transfers of blocks of students from one course to another, e.g., when a course is cancelled; (3) combinations, which specifiy the grouping of "sub-courses" to meet with a "master course" (e.g., it may be specified that the students enrolled in intermediate machine shop shall be scheduled to meet with the advanced machine shop students for a large group lecture, say on safety practices); (4) teacher list, (5) room list; (6) course data packet, which describes the design of each course offered by the school, the description being in terms of phases (e.g., phase 1 = large group, phase 2 = small group, phase 3 = laboratory, etc.), the meeting pattern of each phase in terms of meetings per week and periods per meeting, the number of sections in each phase, and the teachers and rooms assignable to sections of the phase; (7) student course request forms, which list the courses requested by each student.

After the input data has been received at the computer center, the computer staff and the computer take over the operation of SSSS until the actual generation of a master schedule for the school. A total of twelve different computer programs treat the input data after translation into computer language.

Each computer program is designed to perform highly specialized operations on the data. Each program is also under continuous study and development to keep abreast of opportunities for improvement and to incorporate special features requested by users. For example, SAP (student assignment program) is currently under review to reduce the amount of computer time required in its use, thereby producing a reduction in the cost of schedule construction to schools using the system.

The third stage of SSSS consists of analysis of computer output: student schedules, teacher schedules, room schedules, and a master schedule. If the initial output is satisfactory to the user, the master schedule is considered completed. If the results are not satisfactory, an SSSS school consultant and the user review the sources of dissatisfaction and take corrective action. Often the chances deemed necessary can be incorporated rather easily. At other times, corrective action required computer generation of a second, and occasionally a third, master schedule.

SSSS emphasizes throughout the priority of educational decisions over computer decisions. Wherever possible, choices of optimum fulfillment of pupil requests fall to the professional personnel rather than to the impersonal machinery of computer programs and the computer itself.

In summary, SSSS serves three different functions. First, it is an enabling technology. Second, it requires precise definition of the design of each course offered in the school program, as well as the overall program design. Third, it encourages professional personnel to explore in detail the appropriateness of different arrangements of time, class size, pupil grouping, and use of staff and facilities. Experience with SSSS prompts the school staff to raise their sights about viable alternatives and to request expansion in variability of curriculums and courses.

## Procedures

Setting and Population. The variety of schools included in this demonstration pilot study fell into four basic categories (see "Description" above). The first group consisted of schools which have pioneered programs of course revisions through the use of SSSS as an aid in the generation of conventional schedules. The second group consisted of specialized vocational and comprehensive schools where professional personnel

had signified an intent to remain with conventional scheduling patterns but had indicated an interest in employing computer technology to generate their schedules. The third group consisted of schools that wished to introduce more flexibility in their educational programs but that needed the assistance of the SSSS enabling technology and the SSSS consultants. The fourth group consisted of two schools which indicated a willingness to undertake drastic and extended course reconstruction, pupil grouping, and staff utilization based on the proposals advanced by Bush and Allen(2).

Selection of schools involved the following criteria:

1. Balance of rural, suburban, and urban schools, with special emphasis on schools in which the student population pursues or required extensive and intensive vocational education;

2. Variety in school type -- comprehensive and speciali[illegible]d vocational schools;

3. Variety in grade organization -- junior high schools, junior-senior high schools, senior high schools, post-grade 12 technical and vocational schools;

4. Variety in enrollment -- from 600 to over 2,000 pupils.

The ten secondary schools selected and data pertaining to them are presented in the following table:

| School | Type | Location | Grade Org. | Enroll. | Cat. |
|---|---|---|---|---|---|
| 1. Benson High School | Voc. | Portland, Oregon | 9 - 12 | 2,000 | 2 |
| 2. Southern Nevada Vocational-Technical Center | Voc. | Las Vegas, Nevada | 11 - 12 | 1,000 | 2 |
| 3. Canyon | Comp. | Castro Valley, California | 9 - 12 | 1,000 | 1 |
| 4. Ceres | Comp. | Ceres, California | 9 - 12 | 1,000 | 3 |
| 5. J. F. Kennedy | Comp. | Fremont, California | 9 - 12 | 1,250 | 3 |

| School | Type | Location | Grade Org. | Enroll | Cat. |
|---|---|---|---|---|---|
| 6. Golden | Comp. | Golden, Colorado | 10 - 12 | 800 | 3 |
| 7. Marshall | Comp. | Portland, Oregon | 9 - 12 | 2,100 | 1 |
| 8. Poway | Comp. | Poway, California | 9 - 12 | 750 | 4 |
| 9. Valley | Comp. | Las Vegas, Nevada | 9 - 12 | 2,200 | 4 |
| 10. Wheat Ridge | Comp. | Wheat Ridge, Colorado | 7 - 9 | 1,000 | 3 |

The procedures followed in working with the four classes of schools above shared certain aspects in common but also included certain specific differences. In all four classes, consultants assisted schools at three strategic points: first, with decisions concerning the design of courses which the school would offer; second, in recording input data according to SSSS specifications on the SSSS coordinated forms; third, with analysis of input data, the master schedule, course lists, pupil lists, teacher lists, and room lists. These stages do not consist of one-time consultations but merge together in a continuous flow of working relationships as school and SSSS personnel make decisions regarding course designs, reduce specifications to writing, examine the schedules which the computer generates for them, and as the SSSS staff receives feedback from the schools.

The use of SSSS requires that every course in the school be specifically identified as to size, length of meeting time, number of meetings per week, and type of instructional setting (large-group, small-group etc.). Each and every course can be designed to accommodate the purposes sought by the professional personnel of the school. The consultants help the faculty to focus not only on what is feasible but also on alternatives which the faculty may not have considered.

The preparation of input data is an intricate process, but it is basically a clerical operation. The function of the SSSS consultant here is to acquaint the users with the forms and procedures and to stress the importance of accuracy and avoidance of logical error in reducing decisions on course design to appropriate data processing messages.

Analysis of the resulting schedule data is extremely critical. The computer system produces class lists; teacher, room, and students schedules; and a master schedule. It also signals explicity the individuals for whom all course requests have

not been filled. The proportion of fulfilled requests is an index of scheduling effectiveness. When it is unsatisfactory, improvement in the index of effectiveness requires consultation between SSSS personnel and school users to determine what modifications in the original course specifications can be altered to reduce the proportion of unfulfilled requests.

The singular difference in the process of working with the first three classes of schools and the fourth class is that of source of course specification. In the former instance, the local school staff will prepare its own specifications with the assistance and guidance of SSSS consultants. In the latter instance, specifications are derived from adapting the Bush and Allen proposals for a new design. The relevance of the Bush and Allen proposals to vocational education is two-fold. For the pupil enrolled in the vocational curriculum, the design reserves time in his schedule for continuous study in a broadened area of general education and in guidance. For the pupil enrolled in non-vocational curriculums, the design reserves time for continuous study in the fine and practical arts, which encompass opportunities in pre-vocational and vocationally oriented course work and in guidance.

<u>Advisory Committee</u>: Ten distinguished educators joined the Advisory Committee of the Stanford Project. The Committee's function was that of guiding the Stanford effort. The educators were:

Melvin L. Barlow, Professor of Education and Director of the Division of Vocational Education, University of California, Los Angeles, California

Joseph Bellenger, Director of Vocational Education, San Jose Unified School District, San Jose, California

Nathan H. Boortz, Director of Technical Education, Foothill College, Los Altos, California

Lawrence Meier, Director of Vocational Education, Jefferson County Schools, Lakewood, Colorado

Leon Minear, State Superintendent of Schools, State of Oregon

Clair O'Brien, Bureau of Vocational Education, California State Department of Education

James O'Gara. Director of Vocational Education, Portland, Oregon

C.W. Patrick, President, San Diego Junior College, San Diego, California

Raymond, Sturm, Director of Adult and Vocational-Technical Education, Clark County School District, Las Vegas, Nevada

J. Chester Swanson, Department of Educational Administration, University of California, Berkeley, California

<u>Evaluation</u>. The general strategy of evaluation was to assess the effects on the curriculums in demonstration schools and the economic feasibility of utilizing computer technology for generating schedules. Evaluation procedures were keyed to the objectives stated in the section entitled "Objectives" above, as indicated in the tabulation below:

| <u>Area</u> | Evidence to be Collected Before and After Utilization of Computer Scheduling Technology |
|---|---|
| 1. Curriculum | |
| Introduction of variability in course structure | 1.1 Number of different courses especially those appropriate for terminal students |
| | 1.2 Number of different types of instructional settings provided (large-group, small-group, laboratory, independent study), overall and by separate courses. |
| | 1.3 Extent of variability in course structures within and between subject fields, related to the uniqueness of the subjects. |
| Introduction of variability in course content | 1.4 Extent of variations in course content for different groupings of students. |
| 2. Students | |
| Students will be provided opportunities for and will assume responsibility for their own learning and behavior. | 2.1 Amount of time provided specifically for independent study. |
| | 2.2 Number and types of physical facilities provided for independent study. |
| | 2.3 Use of library resources by students.<br>2.3.1 Circulation<br>2.3.2 Self-initiated reading |
| | 2.4 Use made by students of unassigned time during school day. |
| | 2.5 Use made by students of assigned independent study time and facilities |



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| Area | Evidence to be Collected Before and After Utilization of Computer Scheduling Technology |
|---|---|
| | 2.6 Attendance at school and attendance in class.<br>2.7 Number and types of self-initiated referrals to counselors.<br>2.8 Number and types of self-initiated consultation with teachers generally.<br>2.9 Attitudes about school generally and about specific school tasks.<br>2.10 Number and types of referrals for class disciplinary action. |
| Student selection of and assignment to courses will reflect variability in ability and interest | 2.11 Number and types of different groupings of pupils, over-all and by separate courses. |
| 3. Students and Teachers<br>Students and teacher assignments will provide opportunity for extended individual contact. | 3.1 Number, types, and reasons for face-to-face contact between teachers and students on a one-to-one or small group basis. |
| 4. Teachers<br>Teachers assignments will reflect special competences and division of labor. | 4.1 Extent of assignment of teachers to differentiated responsibilities <u>within</u> their subject fields) which are related to depth of preparation and interest in special areas and which are related to variability in judged instructional competence.<br>4.2 Extent of differentiation in teacher assignments which are related to differentiated responsibilities for planning and conducting lessons. |

| Area | Evidence to be Collected Before and After Utilization of Computer Scheduling Technology |
| --- | --- |
| Teacher assignments will reflect professional preparation and status. | 4.3 Number and type of non-professional tasks performed by teachers and by non-professionals as para-professional assistants. |
| Teacher performance will reflect extended staff cooperation. | 4.4 Number, extent, and type of cooperative activities of teachers within and between subject fields, e.g., team teaching, cooperative curriculum and course planning, cooperative conducting of classes. |
| 5. Administrators<br>Administrator participation in schedule construction will emphasize professional versus clerical decisions. | 5.1 Amount of time which administrators devote to clerical details and decisions in schedule construction. |
| | 5.2 Amount of time which administrators devote to working with faculty as a whole and by departments or planning the educational program, including variability in course content and structure. |
| 6. Cost<br>Computer technology for generating school schedules | 6.1 Cost in money and in time of schedule construction. |



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III. RESULTS

The following are the specific results of the Stanford Project. The results are keyed to the sections above entitled "Objectives" and "Evaulation" but include technological developments in the Stanford School Scheduling System. The results are limited in that the objectives and evaluation procedures were developed as part of a three-year program, only one year of which is reported here:

These results were:

1. Relevant areas for intensive investigation during the final two years of the project were identified.

2. Base line data or pre-data to be used in the before-after data comparison were collected.

3. A computerized technique for curriculum simulation was developed and employed by eight project schools.

4. A multiple regression analysis of scheduling input data was developed.

5. New vocational and vocationally related courses were developed in several project schools.

6. Significant changes in course design were undertaken by all schools employing the SSSS enabling technology for the first time. Notable among these changes was the fact that in nine schools many students had time reserved in their schedules for independent study.

## IV. DISCUSSION

### Identification of Areas for Future Concentration

As the project staff investigated the domain of vocational education they soon discovered that the majority of so called "comprehensive" secondary schools possess only a modicum of vocational programs within their total curriculum. The minimal occupational programs that are available in most schools are frequently on the periphery of the total curriculum and are poorly articulated, if at all, with the over-all educational program.

All too often, the vocational education curricula in "comprehensive" schools were developed without the research, study, and observation of independent, but highly regarded, people of the community -- employers, professional men and women, parents, civic bodies. The non-involvement of these vocational advisory committees has resulted in vocational programs that often prepare students poorly for tomorrow's work world.

In considering the function of the secondary school in preparing young people for a productive role in business or industry, it is useful to distinguish between that part of their educative experience that is concerned with acquiring specific vocational skills and that part which provides a general foundation. When this complementary dichtomy was applied to the curriculums of the project schools, the inequality in the time that a typical vocationally-oriented student spends in each of these curricular areas was accentuated.

The results of a survey conducted in the participating schools in the percentage of total instructional time a typical vocational student presently spends in occupational courses indicated the necessity for a careful and penetrating analysis of the most effective articulation between general and vocational curricular areas. Technical schools allocated from fifty to sixty percent of total student time to general education; while non-technical schools required students to spend approximately seventy-five percent of their time in general education.

Project investigators found that experts in vocational curriculums have utilized time as the conventional criterion for organizing vocational education. Rigidly defined vocational programs, which are a legacy of the Smith-Hughes era, are based upon the assumption that classes meeting less than three hours daily cannot be fully accredited vocational programs.



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Time has never been the only standard, and good vocational educators have long provided individual experiences for students who abilities cause them to differ in the time required to complete a task. However, it appears that the danger in beginning with time as the basic criterion is that the necessary performance skills are sometimes poorly defined or ignored. Staff members frequently found vocational programs defined in terms of specified clock hours of classroom instruction. Inherent in this approach is the notion that time spent in class can be used as a basis for comparing the skills of individuals.

It is the exceptional school and the outstanding teacher who has made a formal attempt to sequentially determine the performance tasks that are requisite to a subject area. Students too often are required to spend the prescribed time for the course, regardless of the individual skills developed. The student too seldom finds activities that lead to greater depth and advancement.

If performance, rather than time, became the basic criterion for curriculum development, then the focus would shift to the individual. It is probable that for some students, more time than is now allowed in a vocational course would be needed to achieve a satisfactory level of skill. However, it is just as probable that some students may need more advanced experiences early in the course as they display special aptitudes.

## Data Collection

One of the significant results of the Project was the collection of base line or pre-data from all project schools. These data will be used to make comparisons between schools employing the SSSS technology and schools which have not employed this technology on a before and after basis for all schools.

During the month of August, 1965, the evaluation team of the Project designed preliminary instruments for obtaining before and after data relevant to the specific hypotheses outlined above. The initial set of instruments was duplicated and field tested at Marshall High School, Girls Polytechnic High School, and Benson Polytechnic High School in Portland, Oregon on September 2 and 3, 1965. Following the field testing, all instruments were critically analyzed and modified to include omissions and improvements. The result was a package of twelve data gathering devices.

On September 22-23, 1965, the instruments were again field tested. Reactions were secured from school personnel at Valley High School and the Southern Nevada Vocational Technical Center in Las Vegas, as well as from personnel from Wheat Ridge Junior High School and Golden High School in Jefferson County, Colorado. Copies of the instruments were also field tested locally at Palo Alto High School, Cubberley High School, and Ceres High School, all in California.

Following a review and critique of the data gathering instruments, visits by members of the evaluation team were made to all Project schools. This was prior to a conference of Project schools held at Stanford on October 21-23, 1965. Part of this conference was devoted to a presentation by the evaluation team on data collection procedures to be followd. The actual collection of data in the schools began after the instruments received approval from the United States Office of Education.

At the end of this first year of Project endeavor, the evaluation effort is focused along two fronts. First is the analysis of data. Precise procedures for data analysis are under study. These include the coding of forms for computer processing, checking of data for accuracy, and the categorization of data collected through interview techniques. Second is a review of the extent to which the instruments have served usefully and comprehensively to assess the objectives of the Project.

Curriculum Simulation Studies.

One of the most promising techniques for using computer scheduling to generate educational innovations is the development of curriculum simulation studies. Simulation permits rapid examination of central theoretical and functional questions. Over the long run, it is anticipated that curriculum simulation will make a more significant contribution to educational development than the basic service of line schedule construction. To date, eight of the Project schools have used the simulation technology in testing the expansion and/or the increased flexibility of their vocational education programs.

A Curriculum Simulation Study encompasses two basic components. First, the staff is permitted an opportunity to analyze a simulated model of an educational design within the context of a specific school. Second the opportuntity is provided for involvement and study by the professional staff in developing

and pretesting solutions to educational problems. Alternatives simulated within the local context allow for analysis of facilities and cost. Data can be generated that can help to answer such questions as: Can the curriculum be expanded? How will suggested changes affect teacher load? How can our present facilities be best used in a particular circumstance? What new facilities will be needed if a new plan is adopted? How much money will different alternatives cost? What is the best combination of resources for given program objectives within a total budget, staff, or facility limitation?

Questions such as these cited were asked by the staffs of all Project schools which had not previously employed SSSS. These staffs used the simulation technology to determine the feasibility of translating their present traditional schedules into SSSS computer generated flexible schedules for the academic year, 1966-67. Input data from the present student populations have been employed in the simulation study. Teachers have been able to arrange various instructional contexts (large-group, small-group, independent study, laboratory) in combinations best suited to the fulfillment of their instructional objectives.

These efforts revealed an important implication for vocational education: SSSS as an enabling technology can now be used to generate models of vocational curricula that can be intensively studied and altered before such curricula are fully implemented in the classroom.

<u>Multiple Regression Analyses</u>.

Construction of a viable high school schedule is a process of continued balance between educational needs and available resources. Thus, any change involving educational design and utilization of resources must be based on complete, sound, and objective data. Confidence in the maximum use of all resources must be established if educators are to risk major curricular innovations. An effective <u>schedule analysis</u> system, therefore, is required for the successful application of SSSS.

To provide this vital scheduling information, a multiple regression study was made based on 45 scheduling resources of (1) school enrollment, (2) course structure design, (3) student scheduling density, (4) teacher scheduling density, and (5) room scheduling density. The regression study produced an eminently satisfactory prediction model for present Project Schools.

The derived regression coefficients permit effective gross educational adjustments to be made prior to building the schedule. A substantial savings in time and dollars is possible as a result of pre-schedule analysis. However, the major advantage rests with the confidence and insight provided the educator who must wrestle with the complexities of change. By applying the same analysis after the schedule is generated, precise knowledge of the variable factors will allow finer schedule adjustments. Procedures for gaining the maximum educational leverage with the least expenditure of educational resources are therby established. Consequently, the potential for implementing change has been substantially enhanced.

By applying these regression techniques to the first Project simulation schedules, substantial improvement were realized. The schedule predictions for three schools were within 3 per cent of their first schedule runs. Each school made gross adjustments prior to schedule construction. The refinements produced superior simulation models. With good initial schedules, the educators in these schools were able to focus their attention upon an evaluation of the educational issues. The added confidence in the analysis data made important priority judgements less hazardous. Further, grasp of the impact of a variety of factors enabled the school personnel to consider a wider array of alternatives for educational change.

As the Project staff digs more deeply into the problems of improving vocational education opportunities, new educational questions arise: How can diversity within vocational education experiences be provided? How can work opportunities within the school day be provided? How can complementary vocational and general educational offerings be best scheduled? To help answer these questions it will be necessary to construct new regression models to enable educators to maximize the effectiveness of their use of SSSS.

## New Courses

Some of the comprehensive high schools associated with the project offered limited vocational education programs. The sparse occupational offerings in these schools were usually located in the business, home economics, or industrial education departments. This combination of factors produced an educational setting where many pupils were deprived of any substantial opportunity for vocational training. The staffs of these schools recognized the inadequacies of their present programs but remained unsure about how to use their limited

resources to resolve this deficiency. There was a pressing need for guidelines for the introduction of a variety of vocational experiences into the curriculums of comprehensive high schools with limited vocational programs.

Using the increased flexibility resulting from the employment of the Stanford School Scheduling System, several project schools introduced additional vocational programs. Valley High School in Las Vegas, Nevada, organized a course in hotel-related occupations and a course in service station management. Ceres High School in Ceres, California, offered new courses in ornamental horticulture, farm-power machinery, and vocational homemaking. Marshall High School in Portland, Oregon, designed a course in horticulture and one in orientation to community occupational needs. Golden High School in Golden, Colorado, introduced courses in electronics and upholstery.

## V. CONCLUSIONS AND IMPLICATIONS

On the basis of the results of the one-year pilot program, the following conclusions and their implications can be drawn:

1. A careful review and analysis by the project staff and the advisory committee of the results of the first year indicate that a proposal for a two-year implementation project should be submitted to the U.S. Office of Education. There should be sufficient evidence at the end of two years to demonstrate the efficiency of applying the Stanford School Scheduling System to vocational education.

2. A broader sample of project schools is needed to guarantee maximum curricular diversity. Specifically, "truly" comprehensive schools need to be added to the experiment. These additional schools will permit the application of scheduling alternatives to more well-established vocational programs.

3. Vocational programs are frequently developed without the close cooperation of educators and the public. It is imperative that local vocational education advisory committees be established for each project school.

4. The vocationally oriented pupil spends a large percentage of his time in the general education curriculum of the school. It is vital, therefore, that general education and vocational education be truly articulated. A penetrating examination of the most effective relationship between these two areas must be undertaken.

5. The traditional criterion for organizing vocational programs has been time. The substitution of a time criterion by a performance criterion would shift the focus of instruction to the individual student. Staff members in selected vocational areas must be assisted in the development of performance criteria for their individual area.

6. Curriculum simulation studies and multiple regression analyses of scheduling input data have proved to be powerful in the schedule development process. Both need further refinement, and curriculum simulations should eventually include facilities.

7. As a result of the increased flexibility brought about by the SSSS enabling technology, several schools were able to add new vocational and vocationally related courses. This implies that the employment of SSSS can result in the availability of a larger variety of vocational experience than has heretofore been possible.

## VI. SUMMARY

Professors Dwight W. Allen, Norman J. Boyan, and Robert N. Bush of the Stanford School of Education, and Professor Robert V. Oakford of the Stanford Department of Industrial Engineering received finanacial support from the U.S.O.E. for a one-year pilot project, "Flexibility for Vocational Education through Computer Scheduling". The Project was initiated May 1, 1965 and terminated July 31, 1966.

Recent legislation for the support of vocational education offers schools opportunities to redesign their programs of vocational and pre-vocational training. In the past, tradition and available scheduling techniques have contributed to a typically uniform use of teachers, time, and space and to a typically uniform pattern of grouping students. It was believed that the relaxation of traditional uniformity would encourage schools to improve their programs of vocational education on three fronts.

First, schools would be able to provide better balance in the total program for vocational students in comprehensive or in specialized vocational schools. Second, they would be able to provide more pre-vocational and vocationally-oriented experiences for pupils enrolled in vocational programs, and vocationally-oriented experiences for pupils enrolled in non-vocational curriculums. Third, they would be able to introduce flexibility in course design which takes account of uniqueness in student ability and interest, teacher talent, and course content through variation in class size, duration of class meetings, number of class meetings per week, and teacher assignment.

The principal goal of the project was to explore the feasibility of improving vocational curriculums and the pre-vocational or vocationally oriented dimensions of non-vocational curriculums by introducing greater flexibility through the use of a computer-based scheduling technology. Ultimately, it is intended that the economic feasibility of using SSSS as an enabling technology for vocational and technical education will be demonstrated.

The project covered two sets of schools, vocational-technical and comprehensive schools, and involved the application of the Stanford School Scheduling System. The schools were selected to provide for geographic distribution; for a balance among rural, suburban, and urban areas; and for a variety in types of schools, grade organization, enrollment, and clientele served.

During the course of the investigation, it became evident that most so-called "comprehensive" schools only have minimal vocational programs which are frequently on the periphery of the total curriculum, and are poorly articulated, if at all, with the remainder of the instructional program. Vocational-technical schools were found to offer rigidly defined vocational curriculums of the Smith-Hughes variety. Three-hour shops appeared to be the general rule. This reliance upon time as a basic criterion for identifying vocational education has resulted in rough or uneven definition of individual performance tasks.

Too often vocational curricula were discovered to have been introduced with little assistance from members of the community. As a result of the non-involvement of local advisory committees there is not a good interface with the contemporary work world.

Base-line or pre-data were collected from all project schools. These data will be used to make comparisons between schools employing the Stanford school scheduling technology and schools which have not employed this technology and for before and after comparison within each school.

The evaluation is focused along two fronts. First, is the analysis of data. Precise procedures for data analysis are under study. These procedures include the coding of forms for computer processing, checking of data for accuracy, and the categorization of data collected through interview techniques. Second is a review of the extent to which the instruments have served usefully and comprehensively to assess the objectives of the project.

As a result of our experience this year, three strategic questions arise about the improvement of vocational education. First; "Can vocational-technical schools and comprehensive secondary schools which offer vocational and technical curriculums provide richer and more balanced general education programs for vocational pupils?" Second; "Can comprehensive secondary schools provide more opportunities for pupils enrolled in non-vocational curriculums to participate in desirable pre-vocational technical or vocationally-technically-oriented experiences?" Third; "Can vocational educators and their

colleagues conceptualize and implement alternatives for the more profitable and productive use of time, student abilities and interests, teacher talent, and school facilities in ways which will result in the more thorough preparation of students for the world of work?

It is our intention to seek a two-year funding to: (1) study the relationship between general education and vocational education; (2) develop performance criteria of achievement for all vocational areas; and (3) delineate procedures whereby minimal vocational experiences can be introduced into schools which presently lack vocational programs.

## VII. REFERENCES


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